NOνA-NOTE-DET-57

NOνA Safety Considerations.

This note summarizes a series of interchanges between NOνA and the Fermilab ES&H Section. In additional, two following notes will deal specifically with the issue of Scintillator Oil Flammability and with the issue of PVC Flammability. The flammability testing was done by Jim Priest, the Fermilab Fire Protection Engineer.

This series of three notes formed the basis of the talk given by Keith Schuh at the January, 2005 NOνA Collaboration Meeting at ANL.

Table of Contents

Charge to Fermilab ES&H Section & Description of Potential NOνA Hazards

I would like advice on fire protection issues, on environmental issues (including byproducts from a fire or from fighting a fire), on the requirements for decommissioning , on "pressure vessels", ….(on whatever else am I missing)…. for the proposed NOνA experiment. NOνA would be located in far far northern Minnesota, 810 km from Fermilab, just south of Voyageur's National Park on the Canadian border. This is 40 km southeast of International Falls. The issues clearly involve the state of Minnesota, but I am asking a simpler question: **What would we have to do to build this device at Fermilab?** A description of NOνA can be found in Appendix B of our proposal, see the June 7, 2004 entry on http://www-nova.fnal.gov/reports_page.html (see also Chapter 7 of the March, 2004 original proposal for other details – you have to ignore all the discussion of particle board in Ch 7 since we have dropped that feature.)

The amounts of various materials are still changing from the Appendix B description, and the current scheme would probably be more like 15.4 m wide by 15.4 m high by 114 m long, made of 32-cell wide PVC extrusions all epoxied together into one large plastic construct inside one large building. The extrusions form a honeycomb-like structure with one layer of horizontal cells followed by another layer of vertical cells and so on. The building would have a 25 m extension on one end for deliveries via truck. There might be as many as eight 15,000 gallon storage tanks inside to buffer the scintillator oil during a 2 to 4 year construction period.

Each 32-cell structure is 5.1 cm thick and 127 cm wide (and of course 1540 cm long) with 3mm thick exterior walls and 2mm thick interior webs. Each extrusion would hold about 720 kg of scintillator oil and all 32 cells are connected together for oil filling, so this is the minimum unit of oil.

The reduction in height/width from 17.5m in Appendix B just makes the parts (50' long + ends now) fit on a standard 53' trailer. The thicker walls are the result of our mechanical FEA analyses which leads us to limit the stress in the plastic to 1000 psi maximum when under load from the liquid scintillator. The liquid scintillator load is now at 19 psi on the walls at the bottom of vertical cells.

The material amounts then are:

Rigid PVC – 5,740 metric tons

This contains 15% titanium dioxide, perhaps 5% acrylic impact modifiers, perhaps 3% calcium carbonate, perhaps 3% of an organo-tin compound (e.g. methyltin mercaptide stablizers), and apparently 1% lubricants (waxes)

Liquid Scintillator – 19,260 metric tons

The liquid is mixture of several components:

17,330 metric tons of mineral oil similar to that in MiniBooNE
1,932 metric tons of pseudocumene (or 1,2,4-Trimethybezene)
3 - 6 metric tons of PPO (or 2,5-diphenyloxazole) – about 3.9 metric tons
25 - 50 kg of POPOP (or 1,4-bis(5-pheyloxazol-2-yl)benzene)
50 -100 kg of bis-MSB (or 1,4-bis-(2-methylstyryl)-benzene)

Wavelength shifting optical fiber – 29,462,146 meters, 0.8 mm in diameter

(At a density of 1.05 g/cc this is 13.3 metric tons.)
The fiber is mostly a fluor-doped polystyrene core, clad in a thin acrylic intermediate layer, then on the outside clad in a thin polyfluor (we would use Kuraray fiber exactly like that in MINOS, or Bicron BCF91A is another example).

856,000 channels of electronics using Hamamatsu 16 channel Avalanche Photodiodes.

These "APDs" get about 400 volts applied and are thermo-electrically cooled to -10 degrees C. The thermo-cooler is probably the biggest heat load, maybe 40 watts for 64 channels – still, that's 500 kW distributed in perhaps 50,000 spots over the top and one long side of the detector.

Fermilab
ES&H Section

January 21, 2005

TO: John Cooper, NOvA

FROM: Don Cossairt

SUBJECT: Brief Synopsis of Environment, Safety, and Health Issues Pertinent to the Proposed NOvA Experiment

The purpose of this memorandum is to document for future reference some of the more important environment, safety, and health issues pertinent to the subject proposed experiment. These issues were covered in general terms at a meeting held on December 21, 2004 attended by J. Cooper, D. Cossairt, W. Griffing, M. Logue, and K. Schuh. The major issues will be broken down by topical area, but some overlaps do occur, as indicated in the discussion below. It should be recognized that this note does not intend to present a detailed recipe for resolving these issues. Rather, it is hoped that it will prove to be a useful "shopping list" for subsequent work.

Environmental Protection Issues

1. The proposed experimental facility cannot be built, or funded in a significant way, until requirements of National Environmental Policy Act (NEPA) are met. Given the scope and nature of the facility to be constructed, and the experiment that it will house, an environmental assessment (EA) will need to be prepared. This document is a DOE document, though it would most likely actually be prepared by proponents of the experiment with extensive interaction with DOE staff. DOE makes all the major decisions in the process, including those related to any "public involvement" (e.g., meetings, hearings, etc.). The shepherding of an EA requires efforts of a strong champion within the collaboration. The document needs to cover the following topics:

    - A description of the facility
    - The operations of the experiment
    - The potential impacts on the environment (air and water quality, viewsheds, watersheds, endangered species, discharges to the environment from spills and fires, etc.)
    - Occupational safety issues such as fire, electrical power, ionizing radiation, exposures to chemicals
    - Effects on the nearby population (traffic, noise, dust, etc.)
    - Utility infrastructure requirements and local available capacities
    - Consultations with state and federal government agencies
    - An impacts analysis of "alternatives" meaning a review of other locations that could have been chosen and that of "no action", the choice of not doing the experiment at all
    - Plans for eventual decommissioning of the experimental apparatus.

The conclusion of an EA is generally a Finding of No Significant Impact (FONSI). Project funds of substantial size only become available after the FONSI is issued for the obvious reason that otherwise, DOE would appear to be prejudiced against the "no action" alternative. The other possible outcome is the determination of the need to do the much more extensive Environmental Impact Stateme nt (EIS). The latter option cannot be dismissed *a priori*, but is highly unlikely since the NuMI EA, a document likely to be extensively referenced by an EA for NOνA, resulted in a FONSI. The NuMI EA and FONSI are available on the Internet at:
http://www-esh.fnal.gov:8001/Env/Documents/EAFONSI.pdf.
The NuMI EA is a convenient model to follow as it contains documentation of the various required interactions with government agencies, particularly in Minnesota. Given the location of present preferred choices for the NOνA experimental hall, it is likely that DOE will choose to include the U. S. National Park Service in the U. S. Department of Interior as well as the U. S. National Forest Service in the U. S. Department of Agriculture in the list of agencies in addition to those consulted in connection with NuMI. Obviously, if a Canadian site were to be chosen for the experimental hall, a plan, likely one breaking new ground, for involvement with the Canadian, and perhaps Ontario, governments would have to be developed by DOE. Even for a choice of a preferred site located on U. S. soil, due to the proximity of the international border, DOE may chose to consult Canadian governmental agencies.
It is likely the EA would be heavily focused on the environmental issues (see b elow) associated with the experiment proper, since the neutrino production machinery (i.e., the NuMI beamline) have already addressed in the NuMI EA for the MINOS experiment.

2. The large liquid scintillator inventory of the experiment appears to be the most important issue from an environmental protection standpoint due to the need to develop a credible plan for monitoring, limiting, and containing spills. One needs to be able to monitor, probably in real time, the inventory of liquid scintillator, identify any leakage that might occur, and implement protective measures in a timely manner. Appropriate countermeasures should be built into the experiment as reliance on the local emergency response personnel in this rather remote, near-wilderness area are likely to be volunteer firefighters inadequately prepared or equipped to respond to large spills of this sort of chemical. Modularization of the detector to limit the volume of credible spills and to reduce the "pressure head" associated with them is hig hly recommended. Given the remote location, somewhat unique hazards probably need to be identified and mitigated if credible. As an example, the possibility of gunshots by vandals providing a means of initiating a spill event was mentioned in our discuss ion on December 21. Environmentally sound and safe management of the liquid scintillator inventory is probably the most significant issue to be covered in the EA and the countermeasures to address it may draw considerable interest from DOE and the government agencies consulted during the NEPA process. State and local government laws, ordinances, and codes may be applicable and should be explored as part of the NEPA process.

Safety Issues

1. The Fermilab safety assessment process will need to be followed in accordance with Chapter 2010 of the Fermilab ES&H Manual and is provided at the following website: http://www-esh.fnal.gov/FESHM/2000/2010.pdf. Given the cost and scope of this project, the preparation of a preliminary safety assessment document (PSAD) would be required. The recently completed PSAD prepared by BTEV provides a good model to follow. The ES&H Section staff stands ready to assist in this effort. Other models of SADs are available for reference. The PSAD, and the SAD which follows later, need to comprehensively address all environment, safety, and health issues associated with the experiment. A PSAD is generally a "shopping list" of issues to be resolved with perhaps some early thoughts as to the nature of solutions. The PSAD also addresses environment, safety, and health concerns associated with civil construction of the facility and installation of the experimental apparatus. The SAD is far more comprehensive and has to demonstrate successful resolution of problems. A SAD for a project of this scope and cost requires the concurrence of the DOE Fermi Site Office, supported by a review mechanism of the Fermi Site Manager's selection.

2. The fire safety concerns are current ly being pursued by the proponents in more detail than can be presented here. The extensive use of PVC and the large volume of liquid scintillator material are the major combustible loads. Ongoing tests and engineering analyses should be completed and documented. These will be very important to the development of the PSAD and SAD, and possibly the EA. As mentioned in connection with spill control, the local fire departments in a remote, rural area may not have the capabilities to properly address the worst-case fire scenarios unless welldesigned countermeasures and are installed and prearranged emergency response plans prepared. It is possible that a fire incident could also lead to an environmental event by breaching the vessels and perhaps their desig ned containment. Since this will be a new facility not located on an existing DOE or state site, state laws and perhaps local ordinances and building codes are likely applicable. At an early stage, these need to be identified, likely with the help of DOE since intergovernmental relationships are involved.

3. Electrical hazards, as always, represent an important consideration as they provide possible ignition sources. They also represent considerable heat loads that must be handled. This heat must be dissipated in a safe manner. Obviously, standard electrical safety practices referenced in accordance with the Fermilab set of Work Smart Standards will need to be followed. As mentioned in the context of fire safety concerns, state and local requirements may be applicable and should be investigated for their possible impact on significant detector design features.

4. Pressure safety concerns of great significance arise in direct correlation with the size, and especially the vertical height with its increased pressure head, of the vessels containing the liquid scintillator. This also is tied to those concerns related to spills. These concerns will have to be adequately mitigated in the design by as yet unspecified means, or smaller modules used. In gen eral, smaller modules appear to be preferable to one large tank from this consideration, as well as for spill control.

5. The toxicity of the chemicals used on such a large scale will need a complete industrial hygiene evaluation with identified necessary countermeasures implemented. The handling of these chemicals during filling and removal operations is of special importance as well as those related to emergency responses.

6. The location of the facility makes it clear that plans for the assembly of the detector, the transfer of the oil, and the eventual decommissioning of the facility including the removal of the oil are especially crucial. Those plans, which could be one or several documents, would be very important references to be summarized in the EA, PSAD (at least identified as work to be done), and SAD.

7. While ionizing radiation is not a major concern of this experiment, the use of radioactive sealed sources for detector testing and monitoring in this location on a non - DOE site would require coordination with the State of Minnesota to assure compliance with state, and possibly Nuclear Regulatory Commission, requirements. This would require DOE involvement in achieving a solution mutually acceptable to all parties. Members of the ES&H Section stand ready to provide further assistance to you as needed.

cc: W. Griffing
M. Logue
K. Schuh
File: NOνA Experiment Proposal

----- Original Message -----
From: "John Cooper" <jcooper@fnal.gov>
To: "J. Donald Cossairt" <cossairt@fnal.gov>
Cc: "John Cooper" <jcooper@fnal.gov>
Sent: Friday, January 21, 2005 2:49 PM
Subject: Re: NOvA Tests

Don,
Thanks for the document. There are some specific questions I was hoping you would address, again from the perspective of "Can we build this at Fermilab?":

1. Can your environmental expert comment in particular on the list of chemicals? Are they hazards or not? Are they toxic or not? Are they likely to be declared hazards or toxic in the next 10-20 years or not? Are they on hazard / toxic lists already elsewhere in the world? -- Does that matter? I attach the list again.

2. Would the liquid scintillator volume likely require a containment area for the whole volume? Or can one really successfully argue that "credible" spills are smaller and so do less? If having a modular detector helps, should we be looking at modules with 16 interconnected cells instead of 32 cells to limit the credible spill to 350 kg instead of 700 kg?

3. If we have a leak, what kinds of countermeasures might we have to take other than containment?

4. Would a fire incident require that the containment volume be sized to hold all the scintillator AND any water used in fire fighting?

5. What options other than water exist for fire fighting? Are they expensive? I've heard of foams, but are they a disaster to clean up later? One can inert parts, e.g. electronics boxes or other more modular parts, is this viable?

6. I assume Jim will offer an opinion about the flammability of the device. It would be nice if he could do this in the context of some well known standard.

7. Is it possible to put in a paragraph on the differences between contaminating water deep underground vs. contaminating surface water? What was the NuMI experience?

8. Could you please mention the "pressure vessel" concern as a non-issue?

9. Did any other specific concerns (like the gunshot issue I brought up) come to mind as you thought about this? Let me list a few to stir your thoughts:

Should we have an inside truck receiving area adjacent to the detector or not? e.g. could separate it by a giant fire door.

Should the storage tanks for scintillator oil before filling the detector
be in the same building or not?

Would you have preference for filling such a device at fill points spread over a football field area vs. some one smaller area for some modular scheme? Why?

Would you advise that a tech work area be in the hall with the giant detector or separate from it? I'm fishing for just how dangerous you think this enterprise might be.

Thanks, I know these are hard to answer very specifically or quantitatively without a lot of work.

I'm looking for your best estimates / advice, not gospel.

John

----- Original Message -----
From: "Paul Kesich" <pkesich@fnal.gov>
To: "Don Cossairt" <cossairt@fnal.gov>
Cc: "Mary Logue" <grace@fnal.gov>
Sent: Monday, January 24, 2005 12:45 PM
Subject: Fw: NOvA Tests

General Environmental Concerns:

Construction Phase
Depends on where it will be constructed.
NEPA environmental assessment.
Waste stream evaluation should be conducted.
If wetlands are involved it will require a permit and potential construction of new wetlands.
If over an acre in size it will require a state NPDES construction permit and stormwater pollution prevention plan.
If there is a potential for lose of any of the oil, special precautions will need to be imposed to eliminate or control the
hazard.
If impact to cultural resources than this will need to be addressed through the state with potential additional
characterization, placement of controls, etc.
NuMI had special issues because of construction in the class I aquifer which is composed of dolomite.
Special precautions should be taken during fill-up phase to reduce any potential for release. Any release requires cleanup
and disposal.

Operation Phase
Depends on potential to emit and again where on the site it is constructed.
Surface water emissions may require a modification to our sitewide NPDES permit, it depends what is in the water, ie.
chemical, rad, heat. This is for normal not spill releases.
Potential to emit oil to surface waters outside of our control from a systems failure will require a SPCC plan. (MiniBoone
gets by this with secondary containment to control any potential emission from catastrophic system failure).
Air emissions might require modification to our sitewide lifetime permit, we will at least need to know how much, again it
depends on what it is, ie. chemical, particulate, radiation.
Potential to activate soil will need to be addressed through controls, ie. shielding and monitoring system.
Waste stream evaluation should be conducted.
NuMI's surface water issues will be wrapped up into our sitewide NPDES permit. It also is a special case because of
construction within Class I aquifer.

Specific Concerns:

>>> 1. Can your environmental expert comment in particular on the list
>>> of chemicals? Are they hazards or not? Are they toxic or not?
>>> Are they likely to be declared hazards or toxic in the next 10-20
>>> years or not? Are they on hazard / toxic lists already elsewhere in
>>> the world? -- Does that matter? I attach the list again.

17,330 metric tons of mineral oil similar to that in MiniBooNE
Any release of oil that results in a sheen to uncontrolled surface waters would require an emergency release notification as
well as cleanup. If it is only to our controlled system it is just a costly cleanup. Remember recent CHL release to Bullrush
Pond. FESHM 3010 has DOE reporting requirements. Any release to soil would require cleanup (the designation of the resulting
waste and its cost for disposal is another issue).

1,932 metric tons of pseudocumene (or 1,2,4-Trimethybezene)
1,2,4-Trimethylbenzene evaporates when exposed to air. It dissolves only slightly when mixed with water. Most direct releases of 1,2,4-trimethylbenzene to the environment are to air. It also evaporates from water and soil exposed to air. Once in air, it breaks down to other chemicals. Microorganisms that live in water and in soil can also break down TMB. Because it is a liquid that does not bind well to soil, 1,2,4-trimethylbenzene that makes its way into the ground can move through the ground and enter groundwater. Plants and animals living in environments contaminated with TMB can store small amounts of the chemical.

A release to surface water, as a result of a spill, would not be bad on its own (not mixed with anything else).

3 - 6 metric tons of PPO (or 2,5-diphenyloxazole) - about 3.9 metric tons
Is classified as hazardous on MSDS and requires cleanup and disposal. We have this onsite already. The MSDS says TSCA
chemical.

25 - 50 kg of POPOP (or 1,4-bis(5-pheyloxazol-2-yl)benzene)
Not an environmental hazard on its own.

50 -100 kg of bis-MSB (or 1,4-bis-(2-methylstyryl)-benzene)
No information available. Should check for MSDS.

Secondary containment of all is the best answer.

>>> 2. Would the liquid scintillator volume likely require a containment
>>> area for the whole volume?   Or can one really successfully argue that
>>> "credible" spills are smaller and so do less?   If having a modular
>>> detector helps, should we be looking at modules with 16 interconnected
>>> cells instead of 32 cells to limit the credible spill to 350 kg instead
>>> of 700 kg?

MiniBoone has 100% containment. Removing the pathway to the environment for any potential spill source is the best answer. That
means surface and subsurface.

>>> 3. If we have a leak, what kinds of countermeasures might we have
>>> to take other than containment?

Keep it from getting into the environment. That means surface water as well as soil. Again depending on where the facility is
located, any type of spill into the environment is costly, especially when it comes to oil, remember CHL. If it is within the
site control area it means less of a nightmare but is still costly. If it gets offsite we are looking at bigger problems besides
cleanup (public relations).

>>> 7. Is it possible to put in a paragraph on the differences between
>>> contaminating water deep underground vs. contaminating surface water?
>>> What was the NuMI experience?

The difference between surface water and groundwater is very big especially if you mean at the depths of NuMI which is in the
Class I groundwater. There is really no allowance for release to the aquifer. With NuMI we contend that because of the inward
gradient imposed on the aquifer, all activation products are brought into the tunnel where they are then collected and pumped to
surface. If the release is to the fine-grained Quaternary deposits (Class II groundwater) it is a transport question (this would
dictate the need for cleanup). Again, control of potential for release is the key. No release, no problem.

> > ----- Original Message -----
> > From: "John Cooper" <jcooper@fnal.gov>
> > To: "J. Donald Cossairt" <cossairt@fnal.gov>
> > Cc: "Keith Schuh" <schuh@fnal.gov>; "John Cooper" <jcooper@fnal.gov>
> > Sent: Tuesday, January 25, 2005 9:44 AM
> > Subject: Re: NOvA Tests
> >
> >
> >> Thanks. On point #7 I was interested in the NuMI experience but

> >> really after contrasting a surface site with a deep underground mine
> >> site like Soudan.
> >>
> >> John

----- Original Message -----
From: "Paul Kesich" <pkesich@fnal.gov>
To: "J. Donald Cossairt" <cossairt@fnal.gov>; <jcooper@fnal.gov>
Sent: Tuesday, January 25, 2005 12:11 PM
Subject: Re: NOvA Tests

> Really the difference is the same. You are looking at either work done within a designated aquifer or work done in a formation
> that is not considered viable as a source of drinking water. Work in an aquifer usually requires nondegridation of a resource.
> This is a state thing for the most part and depends on how that designation is made. If you are not in an aquifer you are looking
> at how is what you're doing a potential for impact to anything around it that is, which comes down to a transport question.
>
> Paul

----- Original Message -----
From: "Dave Pushka" <pushka@fnal.gov>
To: "Mary Logue" <grace@fnal.gov>; "John Cooper" <jcooper@fnal.gov>
Cc: "Don Cossairt" <cossairt@fnal.gov>
Sent: Monday, January 24, 2005 2:30 PM
Subject: Re: NOvA Tests

- Hi Mary, John,
  >
  > If the pressure measured at the top of the scintillator container is less
  > than 15 psig, then ASME VIII Division 1, Part U-1(c)(h) would cause this
  > detector to be in a class of vessels which are not included in the scope of
  > the Division. This does not mean that one could not use the hydrostatic
  > head of the liquid scintillator in determining the wall thicknesses (you
  > should!!) and it does not mean that the scintillator may not be designed and
  > code stamped as a pressure vessel (it could). It just means that we would
  > not be obligated to have the scintillaor container 'code stamped'.
  >
  > Hope this helps,
  > Dave
  >
  >
  > ----- Original Message -----
  > From: "Mary Logue" <grace@fnal.gov>
  > To: "Dave Pushka" <pushka@fnal.gov>
  > Cc: "Don Cossairt" <cossairt@fnal.gov>
  > Sent: Monday, January 24, 2005 9:57 AM
  > Subject: Fw: NOvA Tests
  >
  >
  > > Dave,
  > >
  > > Can you give John Cooper a bit of assistance? His is planning a project
  > (NoVA) and would like some advice on whether he has
  > > pressure vessel issues that needs to be addressed in the planning stage.
  > See his attached description.
  > >
  > > If you reply to him directly, could you copy me?
  > >
  > > Thanks.
  > >
  > > Mary

Advice from the PPD ES&H Group on Scintillator Oil Handling

(Eric McHugh, Nov,2003)

Ash Creek Bicron BC-517L transfer considerations

BC-517L contains a slightly hazardous substance (pseudocumene at possibly higher levels than previously expected, Approx. >30% as compared to ~5% as stated in the pre-planning narrative.

-BC-517L is a class II flammable.
-BC-517L according to NFPA is a health hazard of 1 (slight health hazard),
-BC-517L according to DOT is a Class 2 hazard for transport,
-Psuedocumene has a LD 50 of 5000mg/kg (moderately toxic). Health effects: Irritant eyes, skin, nose, throat, and respiratory system. May produce drowsiness, fatigue, dizziness, and other complications.

Transport

What form of transportation will be used to transport the mineral oil from point of origin to ultimately Ash Creek, Minnesota site?

- Semi tanker loads will be expensive and need secondary containment at point of origin and point of transfer.

- Rail tanker loads will need secondary containment at point of origin and point of transfer. The rail will either have to be extended, as in the case of our railhead, or there would be a transfer to a semi tanker (where there would have to be secondary containment at the rail-semi transfer site and at the final destination transfer site).

  - According to the Miniboone transfer project (tankers used for the transfer were 23,500 gallon rail tank cars and 7,000 gallon tanker truck trailers). This would bring the grand total to 98 rail tank cars and 329 truck trailer loads to transfer the oil.

- Minnesota may require site surveys performed to determine the environmental risks and travel of a spill. Spill protection of waterways and the surrounding environment will have to be considered and/or protective barriers constructed. EPA and Minnesota release and environmental protection guidelines must be consulted.

- A Spill Prevention, Control and Countermeasure (SPCC) Plan will have to be constructed by a professional engineer according to (40 CFR 112) attached (Document 1 and 2).

- Detailed transfer procedures must be drawn up for each transfer site (Document 3,4,5,and 6); training and retraining intervals must be planned (disregard of procedures, possibly due to lack of retraining, contributed to the incident and consequential shut down of Gran Sasso).

- A decommissioning plan/procedure must also be drawn up.

The off gassing and potential burning of PVC (HCL gas) should also be considered. The corrosive nature of the gas may damage air handling and other sensitive equipment.

These points need to be considered when planning the transfer of this chemical from point of origin to final destination.